THERMAL METAMORPHISM

Only a brief study was made of thermal metamorphism associated with the Royal George Granite Complex. Biotite hornfels is the maximum grade of metamorphism and appears to be normally achieved only in sediments within about 100 feet of the contact. Specimens 34522, 34524, 34526, 23427, 34528 and 34529 are examples of the contact metamorphism. The clay matrix of the sediments has been completely, or almost completely recrystallized, commonly to fine-grained muscovite and sericite. Biotite is developed only in specimens 34522 and 34527. In the latter specimen, biotite is apparently developed in fine sandstone while lutite (?) in the same thin section has been converted to muscovite and light greenish-brown chlorite. The difference could reflect:

1. different original compositions
2. the greater permeability of sandstones to fluids carrying out the metamorphism.

Specimen 34526 is a spotted hornfels, in which the spots consist of segregations of iron ore (Plate 32). Flakes of a pale green pleochroic mica with a high birefringence are also present.

Irregular grains of brown or greenish-brown tourmaline occur in specimens 34522, 34524, 34528 and 34529.

Quartz grains with sutured margins were observed only in specimen 34524.

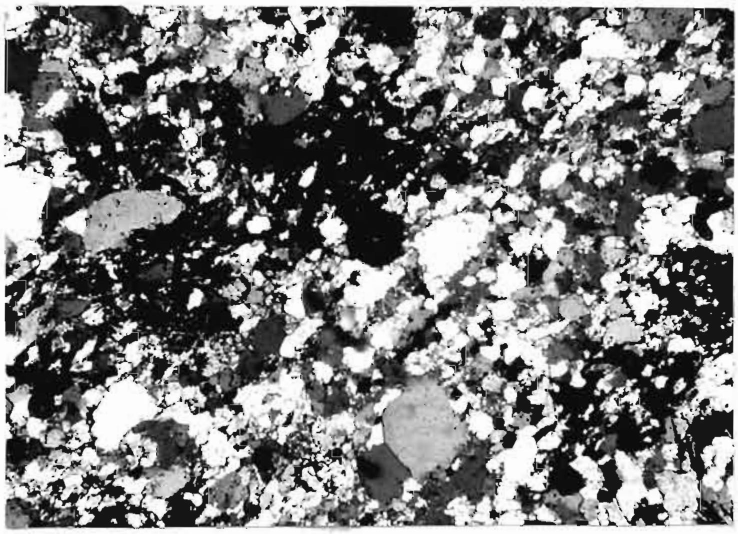

Plate 32. Specimen 34526. Spotted hornfels. Iron ore (black) and quartz and mica (grey). Crossed nicols. x 43

STRUCTURE

Tabberabberan

The Middle Devonian Tabberabberan Orogeny, which preceded the intrusion of the granites, is the only period of major folding to which the area has been subjected. Lack of exposures precluded a study of the folding. However, the small number of strike directions measured in the Mathinna Beds indicate a NNW trend, which almost parallels the trends of the minor folds in the St. Marys area (McNeil, 1965).

Structure of the Permian and Triassic

The most prominent structure is the unconformity between the Mathinna Beds and the Permian sediments. The unconformity is apparently almost planar except for minor undulations, a few feet in amplitude, and possibly some deeper depressions in which the conglomerates were deposited.

The dips of the Permian and Triassic sediments are very similar in the Royal George area, i.e. they are probably disconformable (p. 38). It was not possible to determine whether the boundary between the two was erosional or not. The dips have little relation to the known faulting. Despite the great variation in dips, even over a few hundred feet, it is still possible to observe an apparent damming of the sediments in a zone centred approximately on Brookstead. The origin of this structure is not clear. Although it corresponds approximately to the basement high (Fig. 3) in the pre-Permian rocks, Banks (1962a) would consider the dips of up to 7-10^{o} too large to result from differential compaction over irregularities in the basement. However, the local changes in dip could readily be explained by differential compaction.

Post-Triassic Structures.

Post-Triassic movements have given rise to a number of steeply-dipping, NNE-NE trending, normal faults in the Royal George area.

The largest fault in the area is the Brookstead Fault, which is defined as "that apparently steeply dipping fault, with an east side down displacement of about 400 feet, which extends between 652,440 and 720,545. The age relation of the fault with the dolerite to the north and south of the area is unknown. An un-named fault, near Fingal, with a similar trend described by Nye (1921) may be an extension of the Brookstead Fault.

All other known faults in the area are minor, with a displacement of the order of only 20-100 feet.

MINERALIZATION

Introduction

All the mineralization in the Royal George area is associated with the Royal George Granite Complex. The deposits, which are normally greisens, tourmaline-bearing greisens or quartz tourmaline veins, carry variable amounts of cassiterite and minor sulphide minerals. The first two types are the most important economically.

Controls of Mineralization

The granites west of the Brookstead Fault are commonly unmineralized. It thus seems likely that the mineralized granites east of the fault are situated in the highest portion of the intrusion. The mineralization is confined almost entirely to the granites or to the first few feet of Mathinna Beds above the contact. As mentioned previously (p.46), the mineralization is largely controlled by an early set of joints commonly trending 270°±, but which may strike at up to 320°. In addition, east of the Royal George Mine there are a number of quartz tourmaline bodies, with some cassiterite, striking 50-70°E of the above set (Reid and Henderson, 1929, p.127).

Description of Mine Workings

For the purposes of discussion, the deposits will be subdivided into lode deposits and alluvial workings. The descriptions of the workings are taken largely from Reid and Henderson (1929), with additions from Montgomery (1893a) and Hughes (1956). Only the large deposits and the smaller lodes visited by the writer will be discussed in this report. The reader is referred to Reid and Henderson (1929) for more detailed descriptions of the many minor workings in the area.

Lode Deposits

a) Roy Hill Mine

The mine is situated to the west of Snow Creek, just under a mile south of the Royal George-Avoca road.

The mine was worked on a small scale, between 1893 and 1895, by the Roy Hill Freehold Company. Subsequently it was let out under tribute to Fritz Rubenach, who worked the lode to a depth of 30 feet by open cut. Little work has been done since operations ceased in 1898. Reid and Henderson (1929) quote an estimated figure of at least 100 tons of cassiterite for the total production from this mine.

The workings consist of an open cut, 360 feet long and 10-40 feet wide, and a number of shafts less than 50 feet deep. A hole about 80 feet long, 40 or 50 feet wide and with an unknown depth, has been excavated at the northern extremity of the open cut. The deeper workings are now inaccessible.

Mining and exploration have been largely confined to the western contact between Mathinna Beds and a horseshoe-shaped outcrop of greisened granite. Conglomerates, grits and sandstones of the

Aberfoyle Formation partially obscure the outcrop, particularly near its southern end. Parts of the conglomerate were worked for their detrital cassiterite (Reid and Henderson, 1929).

The greisens range from quartz, with a little mica (e.g. specimen 34871) through quartz-mica greisens (spec. 34872) to quartz-muscovite-pinite rocks (spec. 34885).

The softer greisens in general, and those following the sinuosities of the contact with the Mathinna Beds in particular, were usually the richest in tin (Montgomery, 1893a). However, tin was sometimes found even in the hardest stone (ibid.). The tin had a patchy occurrence. Most shafts apparently had little rich ore below a small depth below the surface.

Although no granites outcrop on the surface, unaltered "aplite" (microgranite?) and porphyritic rock were exposed in the main underlay shaft (Reid and Henderson, 1929).

Montgomery (1893a) regarded the lode as a true contact deposit. That is, it was formed by greisenization of the upper part of a small cupola extending up from the main granite body, which crops out a short distance to the south. However, Reid and Henderson (1929) favour deposition along the intersection of two lines of mineralization, one trending N 15^{o} W and the other an extension of their so called "dyke lode". The "dyke lode", which was not visited by the writer, is exposed in trenches and an open cut about 20 chains east of the Roy Hill Mine.

On the available information it is not possible to estimate the grade or reserves of ore. However, the latter are probably too small for large scale mining. If the lode is a contact deposit, the tin values could decrease at a shallow depth below the top of the cupola.

Exploration should be directed towards determining:

1. The structure of the ore body. That is, whether it is a contact deposit or lode intersection;

2. Extensions of the ore with depth and to the south, under the Permian sediments.

A 250 foot diamond drill hole, situated about 150 feet west of the centre of the open cut and inclined 45°E, should intersect the granite-Mathinna Beds contact, about 90 feet vertically below the surface, assuming an average dip of 55° for the contact. Reid and Henderson's postulated N 15° W lode would be intersected about 150-170 feet below the surface, after drilling 210 feet, assuming a vertical dip.

The southern extensions of the ore body could be tested with a shorter hole, also inclined 45°E, but sited 150-200 feet south of the limits of the workings and 50-60 feet west of the extrapolated position of the ore bodies.

Further exploration should be governed by the results of the above program. If sufficient ore reserves can be proved, the mine would be best worked in conjunction with Royal George Mine.

b) Royal George Mine

The Royal George Mine is situated half a mile south of Royal George. Its history is given in Chapter 3. This mine has been the principal producer in the Royal George area, with an estimated output of 900 tons of tin oxide, most of which was produced by the Royal George Tin Mining Company between 1911 and 1922.

The major rock types are a coarse-grained granite ("graphic granite"?, Reid and Henderson, 1929) exposed in the northern and southern ends of the open cut and a granite porphyry ("quartz porphyry"?, ibid., 1929) cropping out in the centre of the open cut. Minor dykes of microgranite and pegmatite patches and veins are also present. Both the major types also occur in the lower workings.

All the granite types, and particularly the porphyries, exhibit a closely spaced, sheet-like system of joints which strike at about 320° and dip 70-80°SW. The joints provided channels for the greisening fluids. During greisenization, particularly of the porphyries, a zone of silicification, normally a few inches wide, was formed on the joint margins (spec. 34881). This grades through a zone of quartz muscovite greisen into partially greisened rock, giving rise to a banded appearance.

The mineralization extends well beyond the extremities of the open cut. For example, at 717,468, to the south-east, trenches have been opened on quartz-mica greisen veins (usually a few inches wide) in coarse-grained granite. The mineralization also extends to the north-west of the open cut (Reid and Henderson, 1929).

The cassiterite is normally finely disseminated but may occur as infillings in joints in silicified porphyry (specs. 34878, 34879). The secondary uranium mineral metatorbernite ($Cu\ UO_2\ {}_2P_2O_8 . 8H_2O$), has been identified from an incomplete X-ray diffraction run. It is best developed in joint planes in the central portion of the western face of the open cut (spec. 34880), but is sporadically distributed throughout the rest of the mine, occurring even in ungreisened porphyry. No primary uranium mineral has been found in the lower levels (Hughes, 1956), and it is not known whether pitchblende was detected in the deeper diamond drill holes.

Sulphides including pyrite, chalcopyrite and arsenopyrite ar e present, particularly in the lower levels.

The following description of the workings, shown in Fig. 9, is adapted from Reid and Henderson (1929). The ore was won by means of:

1. An open cut, 850 feet long, up to 80 feet wide and averaging 40 feet deep (Plate 33).

2. An adit level (now inaccessible) which extends almost the entire length of the open cut, about 20 feet below its floor.

3. A lower level, 70 feet below the adit level, reached by means of a shaft underlaying 50° to the south-east. (Plate 34).

At about 400 feet along the drives on both levels, the eight foot wide main lode was apparently intersected by a second ore body and the drives were widened to 38 feet, gradually thinning to the southern end. Here the lode apparently splits, becoming uneconomic.

SURFACE & UNDERGROUND WORKINGS — ROYAL GEORGE MINE

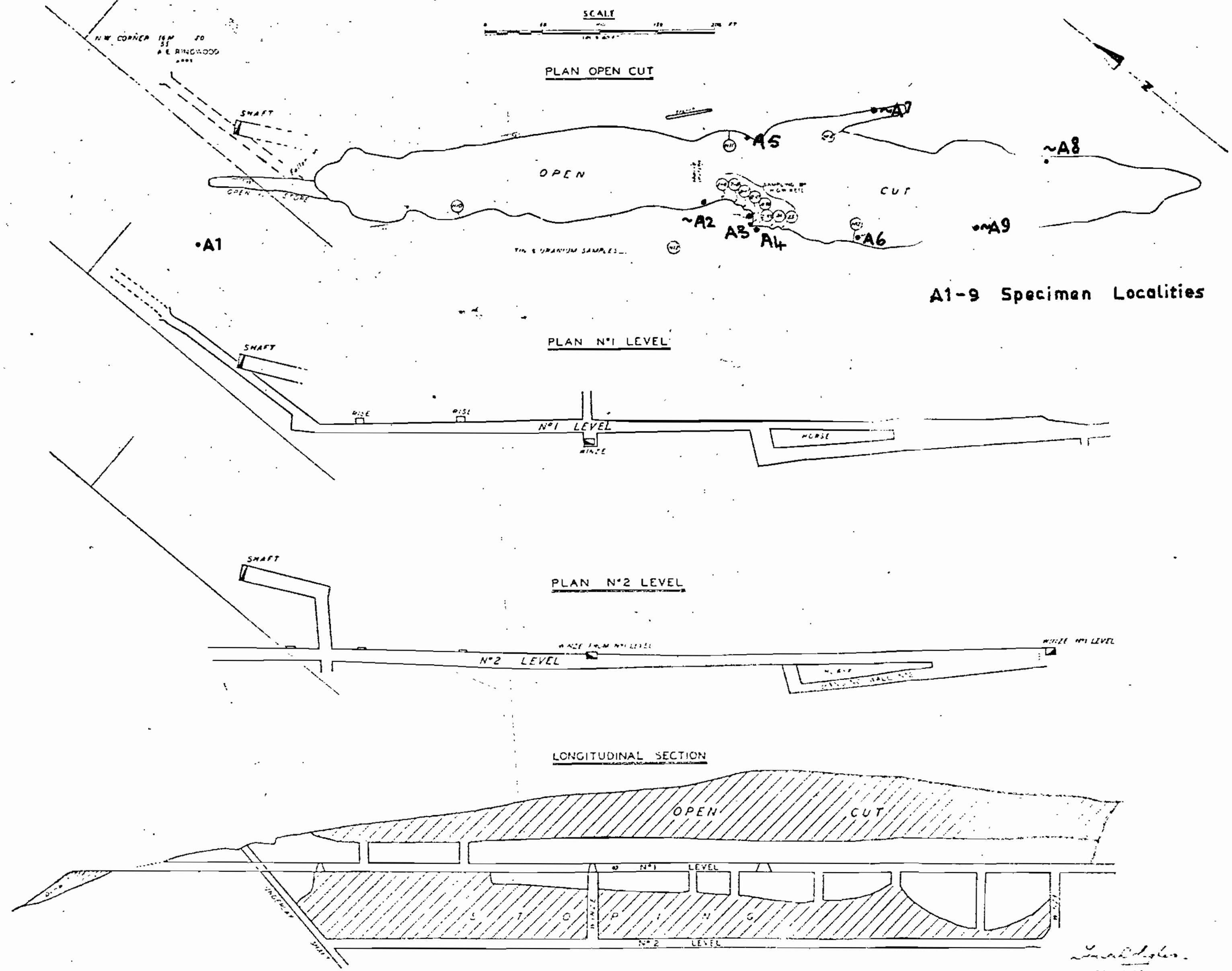

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FIGURE 9 (After Hughes, 1956)

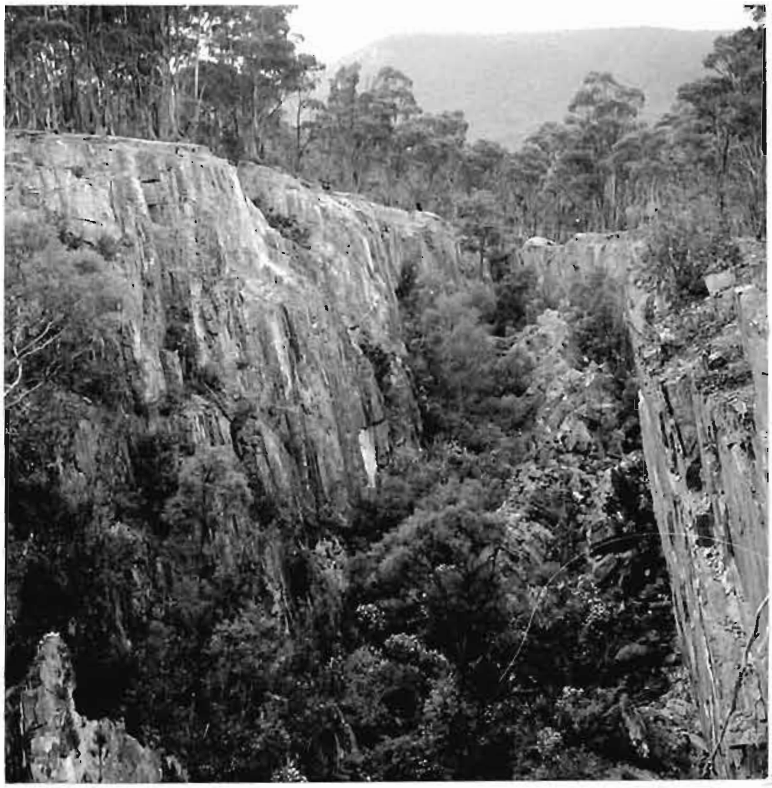

Plate 33. Southern end of Royal George Mine open cut. (Foreground width, 80-100 feet.)

Plate 34. Exploration poppet-head over the underlay shaft to 2 level, Royal George Mine. Entrance to the Adit level is under the lower end of the ore chute.

Most of the developed ore has been stoped out and there has been no development below the lower level.

The present exploration program being undertaken by the Cornwall Coal Mining Company, should delimit the ore reserves in the main vein and any nearby parallel veins. The deposit has a low average grade and would be worked most efficiently on a large scale. This necessitates the proving of substantial ore reserves before proceeding with development.

The uranium could be a by-product of the tin mining if world prices improve, but the reserves are probably rather limited.

c) The St. Pauls Tin Mine

This series of pits and trenches and shafts, referred to as Baileys Lode by Reid and Henderson, is situated about one mile south-west of the Royal George Mine. It was visited by Hughes (1956) in conjunction with the investigation of the "torbernite" in the Royal George Mine.

The workings, now largely inaccessible, were opened up on several east-west coursing veins of fine-grained quartz-tourmaline rock in coarse-grained granite. Cassiterite was apparently present in the greisen bordering the veins, which were barren of ore.

The mineralization is low grade and no further exploration is recommended.

d) Hannah's Prospect

Two forms of lode deposit were noted by Reid and Henderson, namely greisen veins and a "pegmatite body". The former were not examined by the writer, but a brief study was made of the latter, which is situated east of Royal George, at 739,473.

The "pegmatite body" was worked many years ago by means of a shaft and an open cut about 50 feet square. It is reputed that about 17 tons of cassiterite was produced.

Reid and Henderson observed two different ore types, which they regarded as pegmatites, namely:

1. Hard pegmatite consisting predominantly of medium-grained feldspars, pinite (after topaz), quartz, with cassiterite and chalcopyrite. The cassiterite was most common in joint planes but also occurred in small, rich patches with topaz pinite and quartz.

2. "Soft pegmatite" composed largely of altered feldspar and quartz, characteristically with small blebs of tourmaline which give it a spotted appearance. This type crops out in the open cut. Cassiterite is not visible in the rock but according to Reid and Henderson is "fairly evenly distributed throughout the rock in small proportion".

The writer disagrees with Reid and Henderson's identification of these rocks as pegmatites. Instead he regards them as alterations of the microgranite country rock. For example, about 200 feet southwest of the open cut, microgranite grades into a rock resembling the "soft pegmatite", except that it is harder and apparently less altered. A small patch of normal quartz-feldspar-tourmaline-mica pegmatite in this north-west trending alteration zone has also been altered, forming a soft, friable, cassiterite-bearing rock. Specimen 34868 is from a prospect hole 60 feet east of the open cut. Although fine-grained, it is probably a "hard pegmatite", as it contains green pinite, granular cassiterite and no tourmaline. It still contains much feldspar and has a similar texture to a microgranite. The writer considers it to be a partially greisened microgranite (p.).

Exploration of the deposit would be difficult, as the cassiterite distribution is patchy and the alteration zones apparently of limited lateral extent. If a north-west trend is assumed for the main body, then a diamind drill hole 60 feet east of the open cut and inclined 60°SW could be used to test the ore body at depths of about 70 feet. The hole should be at least 130 feet long. The shape and grade of the main zone of alteration could be better visualized if several north-east trending trenches and one south-east trending trench were to be dug to the south-east of the open cut.

However, the deposit although containing some rich pockets of cassiterite, is probably small.

e) Brookstead Area

A number of cassiterite-bearing veins of greisen and silicified granite are exposed to the east and west of Main Creek, near 725,513. Only the Main Creek workings were visited by the writer, and the reader is referred to Reid and Henderson (1929) for a discussion of the other deposits.

The Main Creek workings are situated at 724,513, on the western bank of Main Creek. Operations commenced in 1891, when the Brookstead Tin Mining Company drove an adit on the main lode 271 feet. The company ceased operations and another company took over the mining, reputedly obtaining 1300 tons of ore averaging 2.5 per cent tin. Later groups extended the adit to a total length of 400 feet and sank a winze (now filled with water) 150 feet from the portal. The Christie Lode, about 90 feet north of Main Lode has been driven on 100 feet. Both lodes have been trenched for 500-600 feet up the hill to the west.

The coarse-grained granite country rock is comparatively fresh only a few feet away from the sharply defined (spec. 34889) contacts with the Main and Christie lodes.

Two greisen veins and a coarse-grained quartz-tourmaline vein, with an aggregate width of three feet are exposed at the portal of the adit on Main Lode. However the greisen veins die out rapidly, leaving the quartz tourmaline vein, which persists to the end of the aidt. The quartz-tourmaline vein is only about one foot wide, consisting of a five to six inch wide zone of coarse-grained quartz with radiating tourmaline, and a greisen band a few inches wide on either side. The inner zone also contains minor sulphides, including chalcopyrite, sphalerite, arsenopyrite and galena (Reid and Henderson, 1929), and small amounts of muscovite and fluorite. Specimens of sulphides in vein quartz (spec. 34890, 34891) from the dumps, possibly come from this lode. Reid and Henderson note that, "as a rule the cassiterite is coarsely crystallized, and is disseminated through the body of the gangue." However, no cassiterite was observed by the writer.

The two foot wide Christie Lode is similar to the Main Lode except that it contains up to a few per cent chalcopyrite. The centre of the vein is commonly marked by a zone, a few inches wide, consisting of sugary quartz, radiating tourmaline, fluorite and arsenopyrite. This is best shown in specimen 34886, from the head of a shaft a short distance above the adit.

The Main Lode can be readily sampled along the full length of the adit. However, both lodes are probably too small and, on the whole, too low grade to warrant further exploration.

Alluvial Workings

The creek east of Hannah's Prospect has been sluiced for tin from the main road to 733,468. Several acres of thin residual gravels have been removed south and south-west of Hannah's Prospect. At present, leases over the area are held by Mr. T. Fitzallen and by a Mr. Foot from Avoca. For a number of years Mr. Fitzallen has been working patches of rich ground, just upstream from the main road, which were left by the earlier miners. Apart from limited developmental work, no mining has been carried out by Mr. Foot.

The cassiterite, which is commonly grey, brown or red in colour, tends to be coarse-grained and was probably derived from deposits similar to Hannah's Prospect or from greisen veins on the west of the stream.

The best tin values apparently occur in dolerite shingle, which is overlain by up to six or seven feet of gravels and sands. The largest deposit, over an acre in extent, occurs on the western side of Mr. Foot's lease, between about 470N and 473N. Mining would be restricted by lack of water, as the stream flows only in wet weather. Adequate water could be obtained by pumping from the St. Pauls River, a probably unwarranted expense in view of the small size of the deposit.

b) The valley of a small stream flowing through 747,500 was being mined at the time of Reid's visit in 1928, up to which time about 40 tons of cassiterite had been obtained. The cassiterite is fine to coarse-grained, commonly grey, brown or red in colour and may occur intergrown with tourmaline. Possible sources for at least some of the tin are bodies of schorl rock exposed on the eastern bank near 748,499 and from ore bodies on the hills to the west. The remaining ore reserves are probably small and lack of water is a problem.

c) Alluvial cassiterite occurs in the lower reaches of Main, Bailey and Panel Marsh Creeks, but it has only been worked in Bailey Creek. The writer did not study these deposits, but brief descriptions are given in Reid and Henderson (1929). The deposits tend to be elongate and only one to two chains wide and are reputed to carry up to one- and a half to two pounds of cassiterite cubic yard of wash. However, without recourse to drilling it is not possible to assess the size and grade of these deposits.

e) The Tertiary clays do not carry cassiterite (Reid and Henderson, 1929) and it is not known whether the clays are underlain by cassiterite bearing gravels. The position of the deep lead could be located approximately using refraction seismic methods and its tin content evaluated by drilling. However these Tertiary deposits, if present, are likely to be uneconomic because of the great overburden thicknesses (at least 80 feet near Brookstead).

Conclusions

Although tin minerlaization occurs in much of the granite in the Royal George area, even the largest deposits are not comparable in size or grade with the neighbouring Story's Creek and Aberfoyle Mines.

The Royal George Mine is the most promising prospect, but the Roy Hill Mine and possibly the lodes to the east of the Main Creek workings are worthy of further attention.

Probably one of the greatest restrictions on the development of alluvial mining in the area has been the lack of water. If sufficient ore reserves could be proved to make it economic, water could be pumped from the St. Pauls River. The disposal of tailings creates some difficulty as the St. Pauls River has not been proclaimed as a sludge channel.

It is possible to apply Reid and Henderson's conclusions for the Brookstead area to most of the mining field. Namely that "neither the lode nor the alluvial deposits can be regarded as a whole as being rich or very extensive."

GEOLOGICAL HISTORY

Sedimentation began during the Silurian (?) or Lower Devonian with the deposition of the probably deep water Mathinna Beds. The fine clays and silts were probably deposited under quiet conditions, between periods of turbidity current activity during which deposition of arenites occurred.

During the Middle Devonian Tabberabberan Orogeny, the Mathinna Beds were folded, probably along NNW axes. This was followed by the intrusion of the Royal George Granite Complex, probably in the early Late Devonian. The major granite types (coarse-grained granite, porphyry and the "first generation" microgranites) may have crystallized from a single intrusion or could represent separate intrusions. If the latter is the case, many of the "first generation" microgranites may be the same age as the microgranite dykes intruding the porphyries and coarse-grained granites. Leucogranite dykes were then intruded and pegmatite veins and patches formed. When the granite had largely crystallized, jointing occurred, predominantly on WNW - NW lines, providing channels for the mineralizing fluids concentrated near the roof of the stock. These fluids greisened and tourmalinized the granites and gave rise to the tin mineralization.

After the intrusion of the granites, erosion continued until the Permian, by which time apparently only the roof of the intrusion had been removed. Permian sedimentation commenced, possibly in Middle Artinskian times, with deposition of part of the Aberfoyle Formation, possibly on a sandy, coastal (?) flood plain bordering a high in the pre-Permian surface. The sea level then gradually rose, allowing the deposition of the Castle Carey Mudstone and Burnt Gully Limestone, with the contemporaneous accumulation of Aberfoyle Formation sediments on the flanks of the basement high. However, the high was probably covered, or nearly so, towards the end of the sedimentation of the Grange Mudstone Correlate. The sea probably then receded slightly, only to cover the area again during the deposition of the Risdon Sandstone and the Ferntree Mudstone.

The Permo-Triassic boundary marks a slight break in sedimentation and a change to terrestrial, possibly fluviatile or deltaic, sedimentation. Erosion commenced after the intrusion of the Jurassic dolerite into the Permian and Triassic sediments, and has continued until the present day. During the Tertiary normal faulting occurred and basalts were extruded. The basalts possibly dammed the South Esk and St. Pauls Rivers, causing the deposition of up to at least 80-90 feet of fluvial and lacustrine (?) sediments. Quaternary sedimentation has been confined to the deposition of alluvium, and the formation of talus slopes and some Pleistocene (?) periglacial (?) deposits.

APPENDIX I

Fluorite in the Burnt Gully Limestone

As mentioned in the Stratigraphy (p.29) fluorite is present in a bryozoal calcarenite at 692,531. Although the specimens discussed (34549-34554) were not collected in situ, fluorite is present in a limestone outcrop just to the north-east.

The fine to coarse-grained fluorite is purple, brown or colourless. It most commonly occurs with coarse-grained recrystallized calcite filling cavities in eurydesmid (spec. 34552) or spiriferid shells. Fine-grained disseminated fluorite may also replace the calcite matrix and some fossil fragments (specs. 34549, 34551, 34554, Plate 35).

Fluorite in the cavity fillings commonly has an apparent mutual boundaries texture with the recrystallized calcite (specs. 34550, 34552, 34553, Plates 36 and 37). The interfaces are straight and are parallel to a particular structural plane, in this case the $10\bar{1}1$ plane of the calcite. This texture could suggest that the fluorite and calcite crystallized in equilibrium. However, in specimen 34551 a similar texture has been developed between fluorite and the (earlier ?) calcite lining the cavity. The exact significance of the texture is thus unknown.

The most likely sources for the fluorite would be from originally detrital fluorite, or fluorine adsorbed into clays, in the underlying Aberfoyle Formation, which at this locality contains

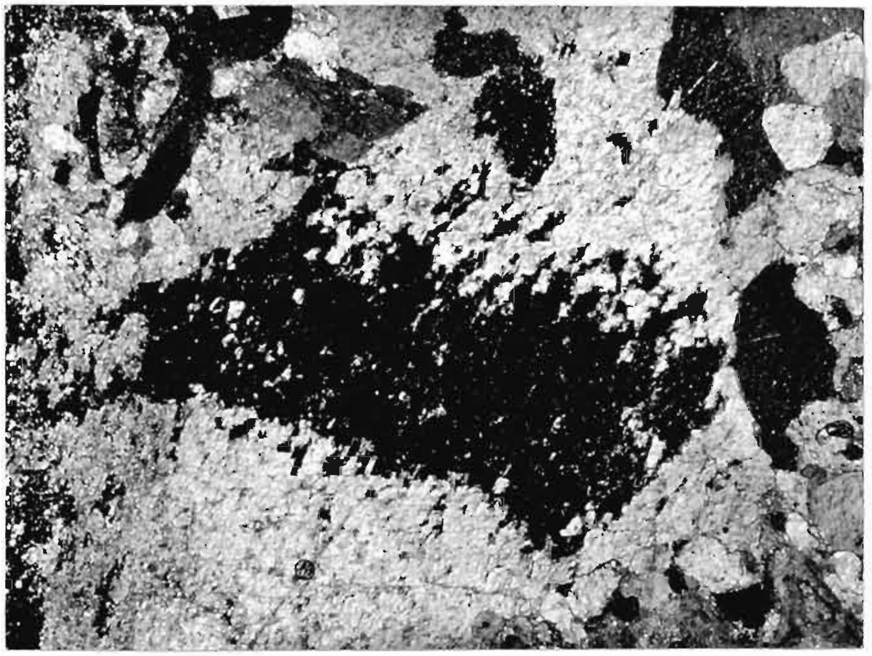

Plate 35. Fluorite (black, centre) replacing calcite (grey) in limestone (spec. 34550). Crossed nicols. x 50.

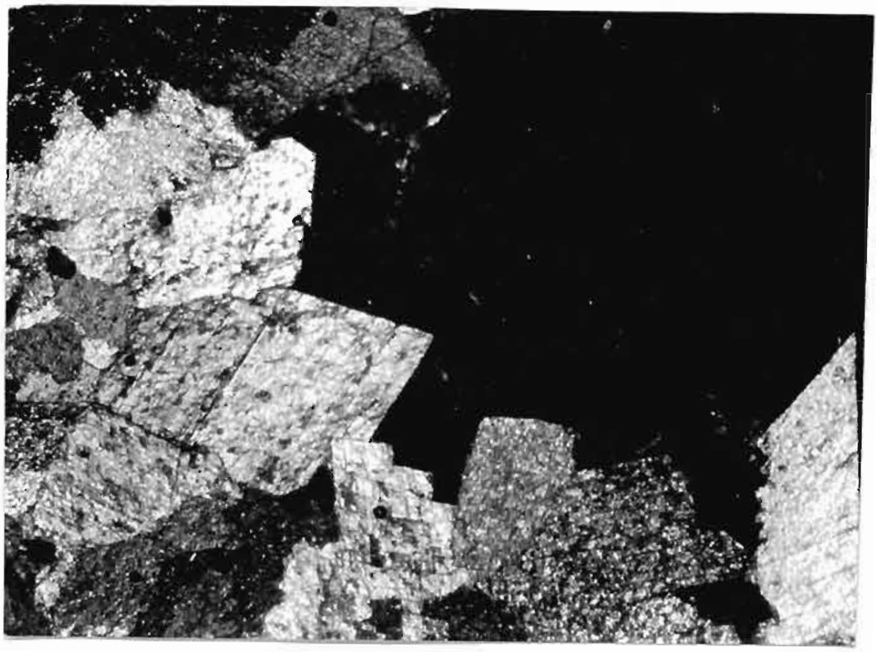

Plate 36. Fluorite (black, right) and recrystallized calcite (grey) in limestone (spec. 34550). Crossed nicols. x 40

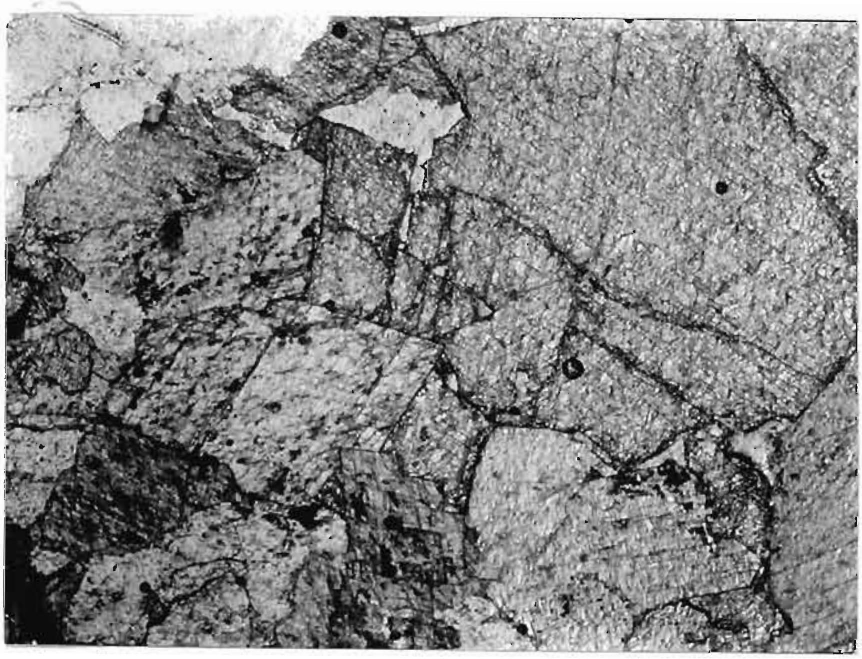

Plate 37. As above, ordinary light. Showing apparent mutual boundaries texture between the fluorite and calcite.

beds of pebbly mudstone. The occurrence of the only fluorite observed in situ, in the basal limestone bed, would seem to support this idea. Additional fluorine could have been derived from the small fraction of granitic debris in the limestone.

The fluorine was probably leached from the Aberfoyle Formation by ground water. It was deposited in limestone concurrently with and/or after the epigenetic recrystallization of the calcite.

APPENDIX II

Theory and Method of Modal Analyses.

Modal analysis involves the estimation of the composition of a rock by counting the mineral grains under the intersections of a graphic or mechanical grid. The composition, as determined by modal analysis, cannot be regarded as representative of the rock as a whole because of counting and sampling errors. As it is essential to have some idea of the accuracy of analysis, when comparing or designing modal analyses, Hasofer (1963) derived the theoretical formula:

$$\sigma^2(p) \leq \frac{44\,p a^3}{R A}\left[1 + 5.8\left(\frac{R}{a}\right)^3\right] \qquad (1)$$

where $\sigma^2(p)$ is the variance ($\sigma(p)$ the standard deviation)

p the proportion of the mineral present (%)

a the grid spacing

A the area counted

R the radius of the mineral grain

n the number of points counted

The total variance $\sigma^2(p)$ includes both the counting and the sampling errors, which are given by (2) and (3) respectively:

$$\sigma^2(p_1) \leq \frac{37\,p a^3}{R A} = \frac{37\,p}{n}\left(\frac{a}{R}\right) \quad \text{(Hasofer, 1963)} \qquad (2)$$

$$\sigma^2(p_2) \leq \frac{4\pi R^2 p}{A} = \frac{4\pi p}{n}\left(\frac{R}{a}\right)^2 \quad \text{(Hasofer, 1963)} \qquad (3)$$

For fixed counts, the total variance has a minimum value for $R/a = \frac{1}{2.26}$ (Solomon and Green, 1965). It increases for higher or lower R/a due to the increased sampling and counting errors respectively.

Solomon (1963), who carried out a number of analyses using artificial models resembling natural rocks, has obtained variances comparable with those predicted by Hasofer's formula.

Method

A number of modal analyses were made of stained slabs and sections of specimens from the Royal George Granite Complex, using ruled grids and a Swifte point counter.

In these analyses, R was obtained using the "traverse intersection" number (Solomon, 1963), and p estimated from a preliminary count of several hundred points. The variances were calculated using (1), or estimated approximately using the chart given by Solomon and Green (1965). Where possible, the analyses were designed for $\frac{\sigma^2(p)}{p} \leq 1$. i.e. for a mineral comprising 40 per cent of the rock, $\sigma^2(p) = 4$, $\sigma(p) = 2$.

The design of the analyses was controlled by the available counting area and/or the single, $1/3$ mm., grid spacing of the point counter. The spacings of the grids, ruled on "Kodatrace", which were used for the analysis of the coarse-grained granites, were such that $\sigma^2(p)$ for each of the major minerals lay within, or near, the prescribed limit. The grainsizes of the microgranites and granite-porphyries were such that it was usually necessary to count at least

3000 points with the point counter. This restricted the analyses to large (300 mm.^{2}+) thin sections. It was not possible to include the phenocrysts of the porphyries in the analyses, as the sampling errors were too large because of the small counting areas available.

In thin sections albite exsolution lamellae were counted only when moderately large. The lamellae in the polished slabs of coarse-grained granite were not visible and were therefore counted as orthoclase.

Identification of the feldspars was commonly difficult where the plagioclase multiple twinning was poorly developed, making it necessary to stain the feldspars. Selective staining of the feldspars (after the method of Bailey and Stevens, 1960) was attempted but was not effective, probably because of the low calcium content of the plagioclases. The potash feldspars were therefore stained using sodium cobaltinitrite (Chayes, 1952).

Experimental Variance for Specimen 34585.

Modal analyses were made of five stained slabs of specimen 34585, a coarse-grained granite. The experimental and theoretical variances were calculated using the formula given by Solomon (1963, p.371) and formula (1) respectively. The results are presented in Tables 6 and 7.

All variances, except that for the plagioclase, are within 0.6 of the theoretical value. However, as two pairs of the faces (1,3 and 2,5) are only about 2 mm. apart and probably have crystals in common (particularly of orthoclase) the variances may be slightly lower than those for more widely separated sections.

TABLE 6

Modal Analysis of 5 Slabs from Specimen 34585

Minerals	Radius (ins.)	Percentage 1	2	3	4	5	mean per cent
Quartz	0.088	28	31	33	20	35	31
Orthoclase	0.154	44	46	46	52	43	46
Plagioclase	0.07	20	18	13	13	15	16
Biotite	0.025	8	5	8	6	7	7
Total counts		613	625	596	642	621	616 (mean)

a = 0.15 inches; the numbers 1 - 5 refer to the slab numbers.

TABLE 7

Theoretical and Experimental Variances for Table 6

	Quartz	Orthoclase	Plagioclase	Biotite
$\sigma^2(p)$ (Exp.)	7.5	11.9	8.1	1.3
$\sigma^2(p)$ (Theoret.)	8.1	23.5	3.8	2.9

APPENDIX III

X-ray Fluorescence Analyses

Sampling and Preparation

The samples were selected for their freshness, rather than by systematic sampling. However, they appear to be representative of the major granite varieties in the complex. The sizes of the samples, which were obtained from single hand specimens, or from composite chip samples over several hundred square feet, are shown in Table 2. Little significance can be attached to the analyses of many of the samples because of their small size (40-80 gm.).

After an initial crushing with a geology pick and separation of the iron fragments using a hand magnet, the samples were reduced to a fine powder in a Siebtechnik mill. The larger samples were split at least twice, prior to the final crushing.

The whole rock analysis was carried out on disks prepared by fusing the sample in a lithium borate mix, after the method of Norrish and Hutton (1964). To prevent dilution of their already low concentrations, the trace elements were analysed in pressed disks of the crushed sample, rather than in fused borate disks.

Procedure

The settings of the Philips X-ray vacuum spectrometer are shown in Table 8. All analyses were carried out under vacuum. Readings of "total counts" rather than of counts/sec., were used for Na_2O and MgO, because of their low count rates.

TABLE 8

X-ray Analysis Settings

	Flow Counter			Scintillation Counter EHT	KV	mA	Peak 2θ	Background 2θ	Counting time:sec	Crystal	Standard	Peak
	Ch.ht.	Ch.w.	Voltage									
Si	19	12	C6, F9		44	20	78.33	75.00	6 x 16	PET	G_1 No.2 (W_1mNo.2)	$K_{\alpha 1}$
Al	22	12	C6, F10		44	20	114.22	111.00	6 x 16	PET	G_1 No.2 (W_1 No.2)	$K_{\alpha 1}$
Fe				C3, F6	48	20	57.38	56.60	6 x 16	LiF	W_1 No.2	$K_{\alpha 1}$
Ti				C3, F5	48	20	85.96	85.40	6 x 16	LiF	Sy_1	$K_{\alpha 1}$
P	22	16	C6, F9		48	20	109.90	105.9	6 x 16	Ge	Sy_1	$K_{\alpha 1}$
Ca	20	12	C6, F6		26 (22)	12	14.32	12.80	6 x 16	PET	G_1 No.2 (W_1 No.2)	$K_{\alpha 1}$
Mg	21	12	C6, F11		48	20	108.82	102.8	6 x 16	ADP	W_1 No.2	$K_{\alpha 1}$
Na	18	16	C7, F1		48	20	72.72	70.50	6 x 16	Gypsum	Sy_4	$K_{\alpha 1}$
K	19	12	C6, F6		34	14	19.78	18.00	6 x 16	PET	G_1 No.2	$K_{\alpha 1}$
Rb				C3, F1	48	20	26.45	22.98 27.48	6 x 16	LiF	Kaolin	$K_{\alpha 2}$
Sr				C3, F5	48	20	24.99	24.40 25.7	6 x 16	LiF	Kaolin	$K_{\alpha 1}$
Sn				C2, F9	48	20	13.89	14.32 13.48	6 x 16	LiF	Kaolin	$K_{\alpha 1}$

Standards:
- G_1 : World standard granite
- W_1 : " " diabase
- Sy_{1-6} : artificial syenite standards
- Kaolin: artificial kaolin standards

Bracketed figures: Settings for dolerite and basalt analyses, where these differ from those for the granites.

Calibration curves of counts against amount (%) of component were plotted, using four standards. The standard used in the analysis of the unknowns was that which lay closest to the curve and/or gave the highest count rate.

The trace elements were corrected for mass absorption by the Compton Scattering method (Reynolds, 1964).

Accuracy

It is not known with certainty why the granite analyses tend to be too low; the sum of the components being as low as 92 per cent for specimen 34590 (Table 2). In comparison, basic rocks analysed by the writer (Table 5) total almost exactly 100 per cent.

The analyses for sodium and magnesium were based on low count rates, with a low peak:background ratio, and are therefore innaccurate. It would be preferable to analyse for sodium by flame photometer.

It is noticeable that silica tends to be lower in analyses totalling less than 100 per cent. This suggests that the silica analyses are a major source of error.

Lanthanum is added to the borate mix to reduce any matrix effects (Norrish and Hutton, 1964). However the matrix effects are still considerable for basic rocks (and possibly also for acid rocks). For example, the SiO_2 and Al_2O_3 values obtained for dolerite and basalt, using G_1 as a standard (bracketed in Table 5) differ from those obtained using W_1 (unbracketed). The discrepancy, although as great as 10 per cent, is normally one or two per cent and is probably due to absorption resulting from the high iron content of the basic rocks. It is thus essential that the standards used have a composition as near as possible to that of the unknown.

The World Standard Diabase, W_1, was analysed as a check on the accuracy of the trace element results. The values obtained and those recommended by Fleisher and Stevens (1962) are:

	Measured (ppm)	Recommended (ppm)
Rb	17	22
Sr	227	220 or 175
Sn	Tr	2 - 3

The sloping background for Rb was determined from two readings, one of which was about 3.5° away from the Rb peak. Errors introduced by a non-uniformly sloping background could be sufficient to account for the discrepancy between the measured and recommended values for Rb. If this is so, the error would be of a similar order for the higher values of Rb encountered in the granites.

The sloping background was probably measured sufficiently close to the Sr peak for non linearities in the background to be negligible. The error is possibly due to an inaccurate standard, or to contamination of W_1. If 220 ppm. Sr is the correct value for W_1, instrumental variation could be sufficient to account for the error.

The writer is unable to explain the low tin value for W_1, as the tin contents obtained for the granites are consistent with normal granitic values.

APPENDIX IV

Specimen Index

The following are details of specimens lodged with the Geology Department, University of Tasmania. The locality numbers 1, 2, etc. and A1, A2, etc. refer to the localities on Figures 11 and 9 respectively.

D.D.H.: Mines Department Diamond Drill Hole No.CA1, Royal George Mine.

* : denotes thin section cut.

M, W, T: denote modal, whole rock and trace element analyses, respectively, carried out.

Catalogue Number		Field Number	locality
	Mathinna Beds		
34521	Lutite (from small roof pendant(?) in granite)	120	13
*34522	Biotite-muscovite hornfels	463	28
34523	Graded siltstone-arenite (hornfelsed)	464	28
*34524	Metamorphosed sandstone		95
34525	H rnfelsed arenite, Glenaire	461	28
*34526	Spotted Hornfels, Glenaire	465	27
*34527	Biotite hornfels, Glenaire	466	27
*34528	Spotted hornfels	358	31
34529	Hornfels with tourmaline	357	31
*34530	Mathinna Beds(?) xenolith in porphyry	123	13
34531	Fine-grained arenite	2Fa	51

Cata- logue Number		Field Number	local- ity
	Aberfoyle Formation		
34532	Fossiliferous feldspathic sandstone		35
34533	Quartz grit, locality unknown		
34534	Fine-grained arkose	3H	42
34535	Fine-grained micaceous sandstone	67	97
34536	Quartz-feldspar paraconglomerate	100	91
34537	Medium-grained arkose	3H	42
*34538	Tourmaline breccia	K14	71
34539	Worm-bored sandstone, Glenaire	472	24
34540	Fine, laminated sandstone	471	25
	Castle Carey Mudstone		
34541	Poorly sorted sandy mudstone	60	92
34542	Conglomerate, Snow Hill		92
34543	Brown, fossiliferous mudstone	95	89
	Burnt Gully Limestone		
*34544	Pebbly calcarenite	46	43
34545	Arkosic sandstone	48	43
34546	Calcareous feldspathic(?) sandstone	130	36
34547	Silicified shelly limestone, locality unknown		
34548	Silicified bryozoal limestone	254	17
*34549	Fluorite in bryozoal calcarenite	134	34
*34550	" " " " , slide only	16	34
*34551	" " " " " "	16	34
34552	Fluorite and calcite in Eurydesma		34
34553	Rhombic calcite and fluorite in calcarenite		34
34554	Disseminated fluorite in calcarenite		34
34555	Fine-grained calcarenite	367	
	Grange Mudstone		
34556	Bryozoal mudstone, Salmon Creek	129	37
34557	Coarse, poorly fossiliferous mudstone	248	16
34558	Weathered Fenestella-rich mudstone	203	60
34559	Fenestella-rich mudstone	50	43
34560	Bryozoal mudstone, Snow Hill	74	94

Catalogue Number		Field Number	locality
	Risdon Sandstone		
*34561	Greywacke (glauconitic)	235	56
*34562	Greywacke (")	243	19
*34563	" "	250	14
34564	Pebbly greywacke with mudstone	202	61
34565	Greywacke	80	94
34566	Pebble greywacke	236	55
	Ferntree Mudstone		
*34567	Greywacke	458	88a
34568	Grey mudstone	78	93
34569	Purple mudstone	79	93
34570	Coarse, purple mudstone	29	46
34571	Sandy mudstone	201	59
34572	Fine-grained argillaceous siltstone	210	63
	Triassic		
*34573	Protoquartzite	228	4
34574	Quartz-pebble, mud-pellet conglomerate	211	64
34575	Quartz grit	215	65
34576	Lithic arenite	217	65
34577	Siltstone	216	65
*34578	Mud-pellet conglomerate	214	65
34579	Lithic arenite	227	4
34581	Micaceous siltstone		69
	Devonian Granites		
*34582	Coarse-grained granite	4	48
*34583	" " " , weathered	35	41
*34584	" " "	111	53
*34585	" " " , M, W, T	298	53
*34586	" " "	87	54
*34587	" " " , with tourmalinized joint	31	45

Catalogue number		Field number	locality
*34588	Coarse-grained granite, weathered, T	118	20
*34589	" " "	127	12
*34590	" " " , W, T	402	2
34591	" " " , powder only, T, 36ft.	CA3	D.D.H.
34592	" " " , powder only, T, 81ft.	CA6	D.D.H.
*34593	" " " , slide only, depth 112ft.	CA8	D.D.H.
34595	" " " , powder only, T, 205.5ft.	CA15	D.D.H.
34596	" " " , powder only, T, 305.6ft.	CA18	D.D.H.
*34597	" " " , W, T	RG7	82, A1
*34598	" " " , W, T	441	98
*34599	" " " , M, W, T; porphyritic	446	101
34600	" " " , porphyritic	350	103
*34601	" " " , (or granite porphyry?)	242	18
*34602	" " " , W, T	9	40
*34603	Porphyry, med.-grained groundmass, M, W, T	413	67
34604	" " " "	RG65	76
*34605	" " "+ "	122	13
*34606	" " " "	225	58
*34607	" " " "	226	57
*34608	" " " " (slide only)	RG35	79
34609	" , (med.-gr g'mass) and microgranite, W, T	K1	83
*34610	" , med.-grained groundmass	K2	83
*34611	"	RG51	84
*34612	"	RG40	78
*34613	" , with pegmatite	RG54	84
*34614	"	RG62	85
*34615	"	RG43	77
*34616	"	387	100
*34617	" , (powder only) depth 13ft.	CA20	D.D.H.
*34618	" , (slide and powder only)T, depth 329ft.	CA21	D.D.H.
34619	"	RG77	73

Catalogue number		Field number	locality
*34620	Porphyry, with large phenocrysts, W, T	447	72
*34621	" " " " ,M	444	99
34622	" " " " , W, T	448	105
*34623	" " " "	5	47
*34624	" " " "	19	49
*34625	" " " "	15	34
*34626	" , T	374	44
*34627	" , M, W, T	396-8	6
*34628	" , M	399	3
*34629	" , W, T	278	5
*34630	Microgranite, medium-grained, dyke	RG11	A9
*34631	" , dyke	RG22	A5
*34632	" , "	RG24	A7
*34633	" , "	RG25	A7
*34634	"	RG28	80
*34635	" , W, T, SW of Royal George Mine	RG31	
*34636	" , slide only	CA1	D.D.H.
*34637	" , slide only, M	e'	D.D.H.
*34638	"	RG69	75
*34639	"	RG70	75
*34640	"	12	39
*34641	"	246	15
*34642	" , T	121	13
*34643	" , dyke		11
*34644	" , dyke		11
34645	" , "first generation"	373	44
*34646	"	258	23
*34647	" , "first generation", T	412	67a
*34648	"	418	70
*34649	" , "first generation"(?), M	424	1
*34650	Aplite dyke, T (see also 34873-5 and 34897-34904)	257	22

Catalogue number		Field number	locality
*34851	Fine-grained leucogranite, W, T	126	11
*34852^	" " " , M		3
34853	Pegmatite (with topaz) in microgranite	RG15	A8
34854	Microgranite grading to med.-gr. pegmatite	416	67
34855	Quartz-tourmaline nodule in porphyry	351	104
34856	" " "	RG30	81
*34857	Fine-grained quartz-tourmaline rock	RG39	78
*34858	" " " " " , vicinity Royal George Mine	RG72	
*34859	" " quartz tourmaline rock	RG74	74
34860	Quartz-tourmaline rock replacing microgranite	364	29
34861	Coarse-grained quartz tourmaline rock	40	38
*34862	Quartz-tourmaline-muscovite rock	417	67
*34863	" " rock with cassiterite	64	96
*34864	Greisen	RG8	A6
*34865	Greisen, Royal George Mine open cut	RG10	
*34866	Partially greisened porphyry	RG5	A2
*34867	" " porphyry(?) grading to greisen	RG2	A4
*34868	" " microgranite with cassiterite	422	70
*34869	Schorl rock, extension of Main or Christie Lodes	315	53a
*34870	Quartz-tourmaline-muscovite rock	290	53
*34871	Greisen	53	95
*34872	Greisen	59	95
34873	Microgranite, powder only, W, T	392	9
34874	" " " , T	393	8
34875	" " " , T, SW Royal George Mine	RG34	
34876	Quartz-tourmaline-muscovite rock, T	280	53
34877	Greisen, powder only, T	CA12	D.D.H.

Cata-logue number		Field number	local-ity
34878	Cassiterite and metatorbernite, on joint plane		A4
34879	" " " " " "		A4
34880	Metatorbernite, joint coating		A6
34881	Greisened porphyry	RG1	A3
34882	Greisened, coarse-gr. granite, stope, N end 2 level	401	
34883	Ore, main lode, N end 2 level, Royal George Mine		
34884	" " " " " " "		
34885	Quartz-muscovite-pinite rock on contact	54	95
34886	"Inner and outer zones", Christie Lode	296	53
34887	Chalcopyrite in inner zone(?) rock, Christie Lode	297	53
34888	Sulphides in quartz rock, dump on Christie Lode	289	53
34889	Quartz rock-coarse-gr. granite contact, " "	291	53
34890	Quartz with galena, dump below adits	301	53
34891	" " sulphides, " " "	302	53
34892	Vein material, 60ft. from portal, Main Lode	112	53
*34893	Dolerite, W	426	66
*-34894	"	2B	86
*34895	Basalt, W	375	102
34896	Vesicular basalt		102
*34897	Microgranite	3D	50
*34898	" , "first generation", M	468	26
*34899	" , medium-grained, W, T	109	88
*34900	" , " "	209	62
*34901	" " "	408	68
34902	" , aplitic dyke	390	10
*34903	" , " " , M, W, T	394	7
*34904	" , " " , M, W, T	370	33

Cata-logue number		Field number	local-ity
	Fossils		
	Castle Carey Mudstone		
88258	Streblastopora marionensis		87
88259	Atomodeama (aphanaia)		30
88260	Strophalosia jukesii; pectinoid, Tomiopsis Sp.		90
88261	Polypora, S. jukesii		87
	Burnt Gully Limestone		
88262	S. jukesii		46
88263	S. brittonii(?)		32
88264	Terrakea, S. britonii		32
88265	Spiriferillina Australis(?), locality unknown		
88266	Grantonia hobartensis		52
88267	Spirifera avicula(?), locality unknown		
88268	Stenopora ovata(?)		34
88269	Terrakea brachythaerus(?)		71a
88270	Eurydhyllum aff. trizonatum, Streptorhynchus		71a
88271	Tomiopsis sp., locality unknown		
88272	Brachiopod (spiriferid), locality unknown		
88273	Volsellina(?) myltiliformis(?)		21